376*a* enters microchannel distillation section **370***a* and flows along interior wall **371***a* as a thin film, as indicated by arrow **373***a*, until it contacts capture structure **372***a*. The vapor phase flows through capture structure **372** into microchannel distillation section **370***a*, as indicated by arrow **312**, and flows through microchannel distillation section **370***a* until it contacts capture structure **372***a*. The vapor phase flow may be driven by a pressure differential. Within microchannel section **370***a*, the liquid phase and the vapor phase contact each other. Part of the more volatile component Y transfers from the liquid phase to the vapor phase to form a component Y rich vapor phase. Part of the less volatile component X transfers from the vapor phase to the liquid phase to form a component X rich liquid phase. The vapor phase flows through capture structure **372***a* into microchannel distillation section **370***b*, as indicated by arrow **313**. The liquid phase flows from capture structure **372***a* through liquid outlet **374***a* through flow passages in the wicking region **332** in liquid channel **330**, as indicated by arrow **335**, into liquid inlet **376**. The liquid phase flows through liquid inlet **376** into microchannel distillation section **370** and along interior wall **371** as a thin film, as indicated by arrow **373**, until it contacts capture structure **372**. The vapor phase flows into microchannel distillation section **370**, as indicated by arrow **311**, and flows through microchannel distillation section **370** until it contacts capture structure **372**. Within the microchannel distillation section **370** the liquid phase and the vapor phase contact each other. Part of the more volatile component Y transfers from the liquid phase to the vapor phase to form a component Y rich vapor phase. Part of the less volatile component X transfers from the vapor phase to the liquid phase to form a component X rich liquid phase. The component X rich liquid phase flows from capture structure **372** through liquid outlet **374** into liquid channel **330**, as indicated by arrow **336**. The liquid phase flowing along line **336** has a higher concentration of component X and a lower concentration of component Y than the liquid phase flowing downwardly through liquid channel **330** into liquid inlet **376***b*, as indicated by arrow **333**. The vapor phase flowing through capture structure **372***b*, as indicated by arrow **314**, has a higher concentration of component Y and a lower concentration of component X than the vapor phase entering microchannel distillation section **370**, as indicated by arrow **311**. Within the liquid channel **330** the more volatile component Y may vaporize and form vapor bubbles that rise upwardly through the wicking region in the liquid channel **330**. This vapor may be drawn into one or more of the microchannel distillation sections (**370**, **370***a*, **370***b*) through the liquid inlets (**376**, **376***a*, **376***b*) and combined with the vapor phase flowing through the microchannel distillation sections (**370**, **370***a*, **370***b*). Heat exchange fluid flows through heat exchange channels **350** and **360** in a direction that may be co-current or counter-current to the flow of the vapor phase through the process microchannel **310**. In one embodiment, the flow of heat exchange fluid through heat exchange channel **350** could be in one direction and the flow of heat exchange fluid through heat exchange channel **360** could be in the opposite direction. The heat exchange fluid heats the process fluids in the process microchannel **310** and the liquid channel **330**.

[0060] The microchannel distillation unit **300**A illustrated in **FIG. 5** is identical in design and operation to the microchannel distillation unit **300** illustrated in **FIG. 4** with the exception that the microchannel distillation unit **300**A provides for the flow of the heat exchange fluid in a cross-current direction relative to the flow of the vapor phase through the process microchannel **310**.

[0061] The microchannel distillation unit **300**B illustrated in **FIG. 6** is identical in design and operation to the microchannel distillation unit **300** illustrated in **FIG. 4** with the exception that the microchannel distillation unit **300**B employs supplemental vapor channels **380** and **386**, and compressor **390**. Vapor channel **386** is adjacent to heat exchange channel **350**. Vapor channel **380** is adjacent to vapor channel **386**. Each of the micro distillation sections (**370**, **370***a*, **370***b*) has a supplemental vapor inlet, for example, a channel or tube (**382**, **382***a*, **382***b*) extending from the vapor phase channel **380** to the process microchannel **310**. Each of the microchannel distillation sections (**370**, **370***a*, **370***b*) also has a supplemental vapor outlet, for example, a channel or tube (**384**, **384***a*, **384***b*) extending from the process microchannel **310** to the vapor phase channel **386**. The vapor phase channels **380** and **386** may be microchannels, and each may have the same dimensions as the process microchannel **310** or the liquid channel **330**. The operation of the microchannel distillation unit **300**B is the same as the microchannel distillation unit **300** with the exception that the vapor phase is recirculated through the microchannel distillation unit **300**B as a vapor phase rather than being condensed and recirculated through the microchannel distillation unit **300** as a liquid phase. The vapor phase flows from compressor **390**, as indicated by arrows **393**, through vapor phase channel **380**, and from vapor phase channel **380** through each of the vapor phase inlet channels or tubes (**382**, **382***a*, **382***b*) into each of the microchannel distillation sections (**370**, **370***a*, **370***b*) where it combines with vapor phase flowing from reboiler **130**, vapor phase flowing from reboiler **130** being indicated by arrows **311**, **312**, **313** and **314**. In the microchannel distillation sections (**370**, **370***a*, **370***b*) the vapor phase contacts the liquid phase flowing along the interior walls (**371**, **371***a*, **371***b*). The liquid phase and the vapor phase undergo a mass transfer in each of the distillation sections (**370**, **370***a*, **370***b*) as described above. Part of the vapor phase flows through the capture structure (**372**, **372***a*, **372***b*) and part of the vapor phase exits the microchannel distillation sections (**370**, **370***a*, **370***b*) through the vapor phase outlet channels (**384**, **384***a*, **384***b*) and flows into vapor phase channel **386**. The vapor phase flows from vapor phase channel **386** back to compressor **390** as indicated by line **394**.

[0062] In one embodiment, a microchannel distillation unit that may be used in any of the above-described distillation columns, including distillation columns **100** and **100**A, may have the construction illustrated in **FIG. 7**. Referring to **FIG. 7**, microchannel distillation unit **400** comprises: liquid channel **415**; process microchannels **420**, **425**, **420***a* and **425***a*; vapor channels **435**, **440**, **445**, **435***a*, **440***a* and **445***a*; vapor inlet/outlets **450**, **452** and **454**; and heat exchange channels **470** and **475**. Liquid channel **415** contains wicking region **416**. The microchannel distillation unit **400** illustrated in **FIG. 10** comprises two microchannel distillation sections, namely, microchannel distillation sections **410** and **410***a*. It will be understood, however, that although the illustrated embodiment depicts two microchannel distillation sections, the microchannel distillation unit **400** may comprise any desired number of microchannel distillation sections, for example, three, four, five, six, seven, eight, ten, tens, hundreds, thousands, etc. Each of the